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TECHNICAL REPORT ARLCD-TR-77051

ILLUMINATION REQUIREMENTS FOR TARGET  
RECOGNITION AND REACQUISITION AS A  
FUNCTION OF FIELD OF VIEW

ROBERT B. DAVIS

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  There exists a general lack of Information on flare effectiveness in the area of target recognition and reacquisition with the unaided eye. To provide some basic Information on this subject, a study was conducted using the Picatinny Arsenal Pyrotechnic Terrain Model. This study examined the relationship between illumination level, target acquisition time, and reacquisition time and the size of the search area.		

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## TABLE OF CONTENTS

	Page No.
Introduction	1
Discussion	2
Method	2
Conclusions	4
Distribution List	13
 Tables	
1     Average acquisition times and reacquisition times at the illumination levels indicated	7
2     Observer acquisition times and reacquisition times at the illumination levels indicated. Observations made at simulated range 790 m (2400 ft), simulated search area .016 sq km (.006 sq mi), visual angle of 11°	8
3     Observer acquisition times and reacquisition times at the illumination levels indicated. Observations made at simulated range 790 m (2400 ft), simulated search area .077 sq km (.026 sq mi), visual angle of 22°	9
4     Observer acquisition times and reacquisition times at the illumination levels indicated. Observations made at simulated range 790 m (2400 ft), simulated search area .152 sq km (.059 sq mi), visual angle of 33°	10
 Figure	
1     Recognition times for three search areas as a function of illumination level	7

## INTRODUCTION

The many parameters of target recognition by flare illumination have been the subject of an extensive investigation conducted by the Feltman Research Laboratory, Picatinny Arsenal. A terrain model of a Southeast Asian locale, constructed at a scale of 160:1, was used in the investigation. The model's terrain features were created so that their spectral reflectances match that of their natural counterparts.

Previous work on this general subject is included in the following reports:

Picatinny Arsenal Technical Report 4075, "Pyrotechnic Terrain Model, A New Dimension in Pyrotechnic Evaluation, Description and Initial Results" Dec 1970, by J. F. Tyroler.

Picatinny Arsenal Technical Report 4184, "Results of an Illumination Requirement Study Using a Pyrotechnic Terrain Model" Nov 1971, by R. B. Davis.

Pyrotechnics Division Information Report 5-72, "An Investigation of the Effect of Changes in Flare Intensity on the Recognition Probability of Vehicular Size Targets" Dec 1972, by R. B. Davis and J. F. Tyroler.

This report, which covers the effect of the size of the search area on target acquisition as well as reacquisition characteristics as a function of time, illumination level, and search area, was prepared at the request of the Target Acquisition Working Group (TAWG) of the Joint Technical Coordinating Group for Munitions Effectiveness, the Naval Weapons Center, China Lake, CA. The purpose of the report is to provide basic information on flare effectiveness in the area of target acquisition with the unaided eye.

## DISCUSSION

In a reacquisition task, an observer is faced with the problem of re-acquiring a target which has already been recognized. In the reacquisition process, much less illumination and time may be required due to the fact that the observer has already acquired the target once and is familiar, generally, with its location, size, and shape. In this investigation, one of the factors examined was the "memory effect," or the extent to which an observer can use the visual clues obtained in the initial acquisition, such as the unique shape of a tank, to assist him in reacquisition. Another factor examined was the effect of search in a more limited area than that of the original search when reacquiring targets which had moved since the original acquisition.

In field conditions, the illumination on target available for reacquisition is variable. However, in this initial examination, the illumination level for the reacquisition of targets was decreased 50% from the level at which they were acquired. The initial acquisition illumination levels selected for recognition were at or above a critical level at which an observer could recognize the target with 90% probability.

In addition, three different size search areas were employed to determine the effect of the size of the search area on the time necessary for the observer to make a recognition. This information could be used to form an analytic expression for application to a more encompassing mathematical model for predicting target recognition.

## METHOD

The observers used for this test were civilian personnel from Picatinny Arsenal. All observers had normal vision, either natural or corrected. Four model targets, a 2 1/2-ton truck, 3/4-ton truck, a tank, and a jeep, were used for the test. The observers were allowed to examine the targets and to become completely familiar with the shape and relative size of each.

The observers were then given an orientation of the test to be performed, the tasks that would be required of them, and the desired response. They were first to describe the vehicle and then give its location as if the search area were a clock face (large truck, three o'clock, halfway to the edge). The observers were then dark adapted for at least 30 minutes, and stationed at the proper distance and elevation for the test.

Three circular search fields were used which simulated areas of .016, .077, and .152 sq km (.006, .026, and .059 sq mi). The observers viewed these search areas at a simulated slant range of 790 m (2400 ft) and an elevation of 11° with respect to the center of the search area. These concentric circular search areas were uniformly illuminated by a device constructed with baffles that sharply defined the search areas. The portions of the terrain model not being used for a given test were in total darkness. The light source was a spectrally corrected tungsten-filament lamp which was color matched to simulate an illumination flare.

Two basic tests were performed. The first was designed to determine the effect of the size of the search field of view on both the time and the illumination required to acquire targets (recognition). In this test, the observer was asked to acquire targets in an illuminated search area where nothing was visible outside that area. The second test was designed to examine reacquisition of both moved and unmoved targets. A group of 20 locations for target placement were preselected so that the observer would have to search the entire field and not focus his attention on the same general location within the overall illuminated area.

In determining the effect of the viewing area, however, only 5 of the 20 locations were selected. Previous work has shown that the illumination requirements for target recognition are such that the angle formed between the illumination source, target, and observer, as well as the change in range from the closer to the farther points in the search area, would produce large changes in the illumination requirements for target recognition. The five locations selected were common to all three search areas and had approximately the same illumination requirements for target recognition.

The observers were presented with the smallest search area first [.016 sq km (.006 sq mi)]. The size of the search area was then increased to .077 sq km (.026 sq mi) and finally to .157 sq km (.059 sq mi)

to present the observer with differing situations. The illumination level for a given test was set and the observer, upon a given signal, would begin his search and make his recognition, whereupon the elapsed time would be recorded.

In compiling the data for the effect of the search area, more than 3500 separate observations were performed by five observers.

In the second test, two types of information were sought: reacquisition of a target not moved from the location of recognition and reacquisition of a target moved, with the maximum distance of the move determined by the distance a vehicle moving at 32 kmph (20 mph) could cover in 10 seconds. The observer was shown a vehicle moving at a scale speed of 32 kmph (20 mph) so that he would have a mental image of the magnitude of this more limited search area.

The look-away time for the observer between the acquisition and reacquisition of a target was set at 10 seconds. A shorter duration was not feasible due to the time required to relocate the targets, and a longer duration was not tactically feasible. Also, the observer was informed that the target would always be within the illuminated area and not moved to a location where it would be invisible.

In this test, the illumination was lowered to one-half that of the acquisition level during the 10 second look-away. The observer then reacquired the target and recorded the time for reacquisition. More than 1600 separate reacquisition tasks were performed by five observers.

## CONCLUSIONS

The results of the effect of the search area on target acquisition are shown in Figure 1. These results show that, as the search area increased by a factor of 10 and for a fixed illumination level such as one footcandle, the recognition time increased only by a factor of two.

An average of all search areas (Table 1) shows that when equal footcandle illumination levels for both acquisition and reacquisition of the non-moved vehicle are compared, reacquisition was made in roughly half the time necessary for the initial acquisition.

In the case of the moved vehicle, however, again comparing equal illumination levels (e.g., .61 fc for acquisition and .61 fc for reacquisition), there is a time advantage for reacquisition. However, this advantage was not quantitatively determined.

The observer acquisition and reacquisition times and illumination levels for each of the individual search areas are given in Tables 2, 3, and 4.

It is clear that both acquiring and reacquiring a moving vehicle, a condition which was not tested, would show lower required illumination levels and recognition times and the data in this report should not be considered to represent this situation.

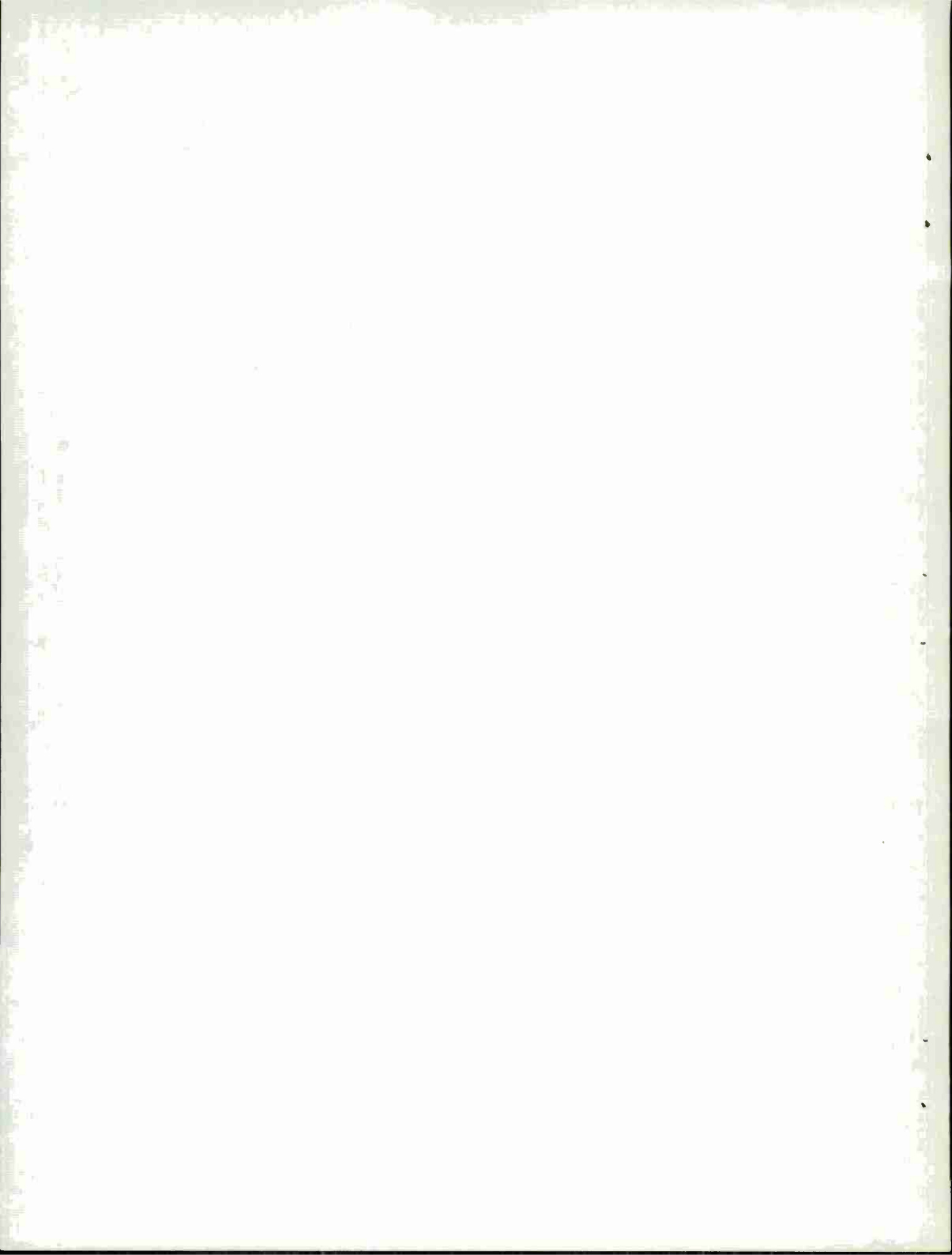


Table 1

Average acquisition times and reacquisition times  
at the illumination levels indicated

<u>Acquisition</u>		<u>Reacquisition</u>			
<u>Level (fc)</u>	<u>Time (sec)</u>	<u>Target not moved</u>		<u>Target moved</u>	
		<u>Level (fc)</u>	<u>Time (sec)</u>	<u>Level (fc)</u>	<u>Time (sec)</u>
2.5	4.7	1.25	2.5	1.25	4.7
1.25	5.3	.61	3.0	.61	6.4
.61	5.9	.31	2.7	.31	6.4
.31	7.7	.15	3.3	.15	6.0
.15	8.8	.07	4.7	.07	9.4

Test Conditions

Look-away time, 10 seconds

Reacquisition always made at 50% of the acquisition illumination level

Critical level of illumination for 90% recognition, 0.25 footcandle

Simulated range, 790 m (2400 ft)

Table 2

Observer acquisition times and reacquisition times  
at the illumination levels indicated. Observations made  
at simulated range 790 m (2400 ft), simulated search  
area .016 sq km (.006 sq mi), visual angle of 11°

<u>Acquisition</u>		<u>Reacquisition</u>			
<u>Level (fc)</u>	<u>Time (sec)</u>	<u>Target not moved</u>		<u>Target moved</u>	
		<u>Level (fc)</u>	<u>Time (sec)</u>	<u>Level (fc)</u>	<u>Time (sec)</u>
2.5	3.4	1.25	2.5	1.25	3.0
1.25	3.6	.61	2.5	.61	4.0
.61	4.6	.31	2.4	.31	3.5
.31	5.8	.15	3.1	.15	3.2
.15	5.9	.07	5.0	.17	8.8

Test Conditions

Critical level of illumination for 90% recognition, .25 footcandle

Look-away time, 10 seconds

Reacquisition made at 50% of the acquisition illumination level

Table 3

Observer acquisition times and reacquisition times at the illumination levels indicated. Observations made at simulated range 790 m (2400 ft), simulated search area .077 sq km (.026 sq mi), visual angle of 22°

<u>Acquisition</u>		<u>Reacquisition</u>			
<u>Level (fc)</u>	<u>Time (sec)</u>	<u>Target not moved</u>		<u>Target moved</u>	
		<u>Level (fc)</u>	<u>Time (sec)</u>	<u>Level (fc)</u>	<u>Time (sec)</u>
2.5	5.4	1.25	3.0	1.25	4.5
1.25	5.3	.61	2.8	.61	7.0
.61	6.1	.31	3.8	.31	8.7
.31	7.8	.15	2.5	.15	7.2
.15	10.3	.07	5.3	.07	8.9

Test Conditions

Look-away time, 10 seconds

Reacquisition made at 50% of the acquisition illumination level

Critical level of illumination for 90% recognition, .25 footcandle

Table 4

Observer acquisition times and reacquisition times  
at the illumination levels indicated. Observations made  
at simulated range 790 m (2400 ft), simulated search  
area .152 sq km (.059 sq mi), visual angle of 33°

<u>Acquisition</u>		<u>Reacquisition</u>			
<u>Level (fc)</u>	<u>Time (sec)</u>	<u>Target not moved</u>		<u>Target moved</u>	
		<u>Level (fc)</u>	<u>Time (sec)</u>	<u>Level (fc)</u>	<u>Time (sec)</u>
2.5	5.2	1.25	2.1	1.25	6.5
1.25	6.9	.61	3.7	.61	8.1
.61	6.9	.31	1.9	.31	7.0
.31	9.4	.15	4.3	.15	7.6

Test Conditions

Look-away time, 10 seconds

Reacquisition made at 50% of the acquisition illumination level

Critical level of illumination for 90% recognition, .25 footcandle

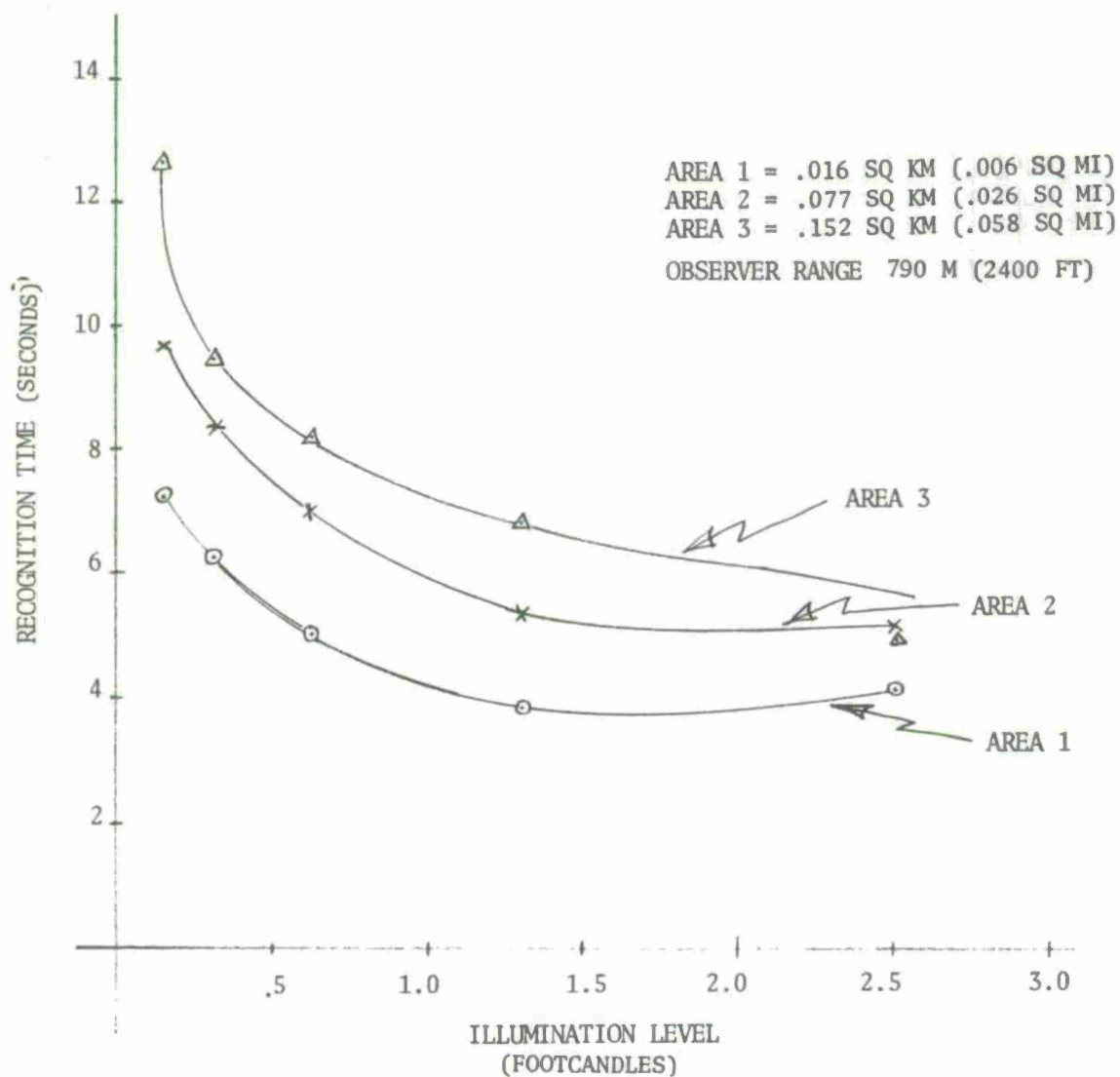
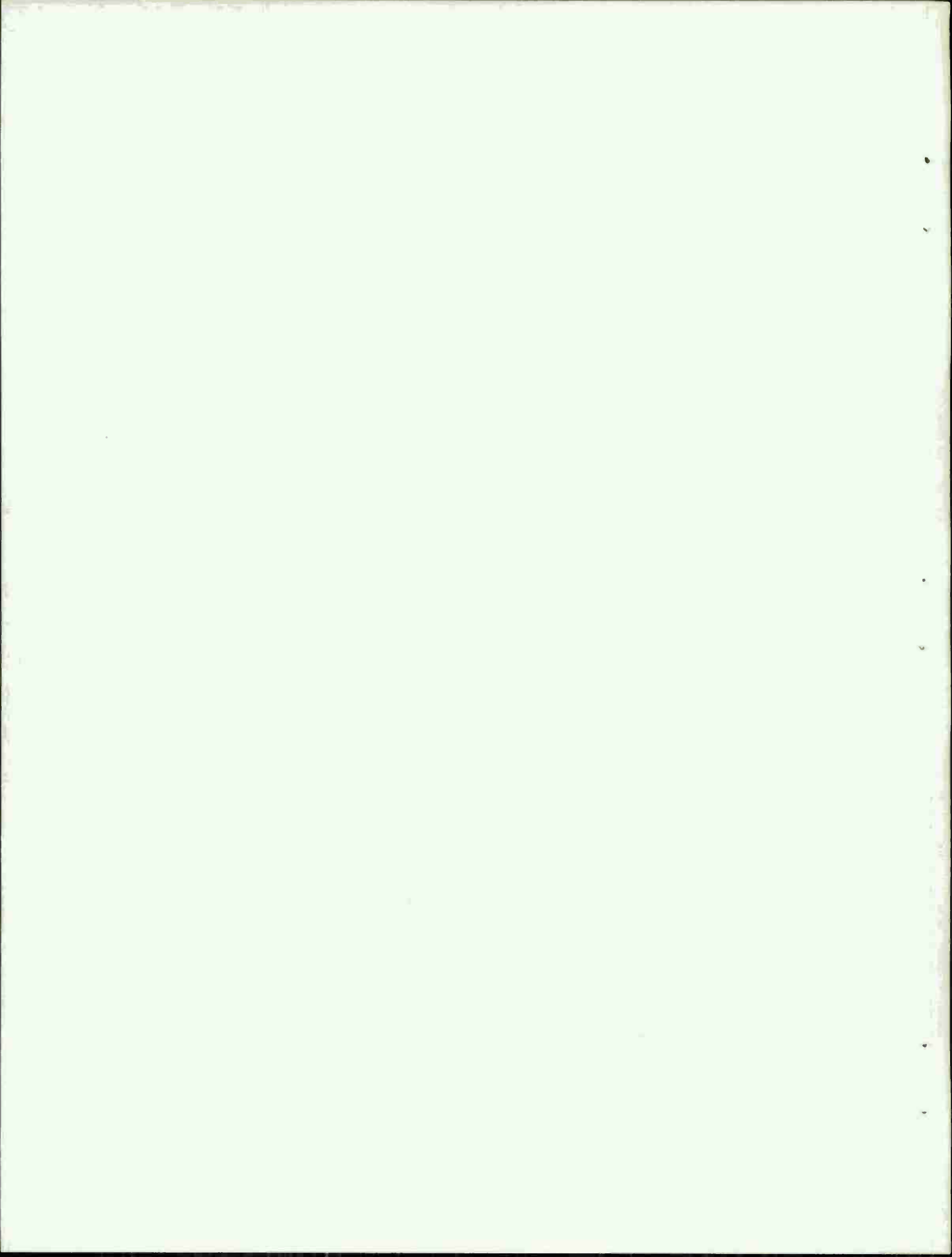


Fig 1 Recognition times for three search areas as a function of illumination level



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